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PALATABILITY OF BEEF AFFECTED BY GRADE AND DEGREE OF MATURITY

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Introduction

Palatability of beef depends quite largely upon the method by which the meat is cooked. There are, however, certain inherent properties in beef related directly to grade, and degree of maturity or the age of the animal when it was slaughtered which affect its palatability, despite the method of cooking. The effects of grade and degree of maturity on the palatability of cooked beef are noticeable, especially in its aroma, flavor, tenderness, and juiciness.

1/ Palatability, with special reference to meat, is defined as follows:

"Palatability: Palatability in any given meat is the degree in which it is acceptable, pleasing, agreeable or satisfying to the palate, with special reference to flavor and tenderness ^{2/} or physical condition as experienced in the act of eating."

Palatability, therefore, includes more than mere taste or flavor. Tenderness, aroma, juiciness, and other conditions in the meat also enter into palatability and may influence the judgment of the consumer regarding its degree of acceptability when eaten. The grade of beef is generally acknowledged as a guide to its degree of palatability; therefore, one of the objectives when grading meat is to have the grade indicate to the consumer as reliably as possible the palatability or degree of satisfaction he may experience when eating the meat.

Until comparatively recent years no well directed effort was made to isolate, identify, and measure quantitatively or qualitatively the factors which contribute to the palatability of beef. Since 1926 meat research workers at many Federal and State college experiment stations have given careful attention to these phases of study in connection with their cooperative meat investigations.

1/ Definition prepared by Committee on Definitions and approved by Committee of Interbureau and State meat research workers October 21, 1938.

2/ Juiciness should have been included.

Available data from those sources with reference to the effects of grade and of the various degrees of maturity on palatability of beef constitute the basis for this discussion. Its purpose is to correlate such data with the U. S. standards for the grades of beef in order that the palatability significance of those grades may be more generally understood.

Grade and Palatability

The grade of meat is a commercial measure of its degree of excellence. Technically, the grade is determined by the evaluation of three grade factors: conformation, finish, and quality. Chief among these is quality. From the consumer's standpoint the quality of the meat and its degree of excellence are the same and provide the most reliable index to its probable palatability when cooked.

The consumer has learned that the palatability sensations experienced when eating low-grade beef are not as pleasing as those from high-grade beef. He has learned also that there are material and significant variations in this respect between these grade extremes which require definite classification for his guidance. When the U. S. standard grades for beef were prepared, one of the objectives was to provide the consumer with a guide by which he could select beef of the palatability desired with greater assurance than had been generally possible previously. Notwithstanding this was an objective when the standards were established. No data were scientifically compiled to show that the grades were an indication of the degree of palatability. Facts learned through trade practice and experience, helped the grader to identify, with a degree of accuracy, the grade of beef and its probable palatability. Research since then, however, has shown that the standard grades as originally established are reasonably reliable guides to the various degrees of palatability of beef.

Degree of Maturity and Palatability

The character of the flesh changes as the animal grows older. The texture, grain, color, firmness, and general appearance of the flesh of veal or calf are not like those of the flesh of mature beef. There are wide differences also in the palatability of cooked meats from them. The changes occur gradually, but are more rapid in the flesh of young animals than in those of yearling and older cattle.^{3/} The palatability sensations experienced when eating veal are not like those experienced when eating beef. The greater the age, the greater is the difference in these respects between the meats of the two age groups.

Because of the differences in the character of the flesh according to degree of maturity, there are differences in the market values of the animals according to their age group, and of the meat cut from them. It is a common market practice, therefore, to classify live animals and when slaughtered their respective carcasses and cuts according to certain general age groups. For instance, live cattle are classified and designated according to such general age groups as Vealers, Calves, Yearling Cattle, and Mature Cattle, and their respective dressed products are classified and designated as Veal, Calf, Yearling Beef, and Mature Beef carcasses and cuts. Other age classifications are observed, but those listed are the most common.

^{3/} Comparison does not refer to bulls, stags, oxen, and old cows but primarily to steers and heifers within the ages at which the bulk of cattle are slaughtered for beef.

Variations in Palatability

The palatability of beef is affected by two independent conditions - grade and degree of maturity. Whether an animal is of high or low grade is at least partly an artificial result brought about quite largely by the attention given to breeding, feeding, and caring for it. Degree of maturity is a natural condition which is also reflected in the character of the flesh. Different combinations of grade and degree of maturity produce variations in palatability, that is, the same palatability reactions are not experienced when eating Choice grade veal as when eating Choice grade yearling beef. The reactions are different even for yearling and mature beef in the same grade. Therefore, palatability sensations vary within the grade according to the degree of maturity. Obviously, they vary also within any age group according to grade.

The beef of a Choice grade 2-year-old steer is much more pleasing to the palate than the beef of a Canner grade steer of the same age. The characteristics in the flesh peculiar to grades, therefore, should be considered in combination with those peculiar to the degree of maturity when selecting beef for the palatability desired. More specific information about the probable palatability of beef is possible when both the grade and the degree of maturity are known than when only the grade or the age is known, even though the grade may be more indicative of palatability than is the degree of maturity.

Meat Palatability Research

IN 21
In order to determine whether there are differences in the palatability of beef according to grades and to age groups and to indicate the approximate extent of such differences, analyses were made of the available reports of Federal and State meat research specialists on the palatability of selected cuts of graded and cooked ribs from Calf, Yearling, and Mature Steer carcasses. ^{4/}The ribs had been graded according to the U. S. standards and cooked according to standardized methods.

The grades of ribs used were Utility and Commercial combined, and Choice. The Choice ribs were from the same lot of cattle from which the Utility and Commercial grade ribs were obtained but were cut from the carcasses of those animals of the lot that had been fed intensively for 5 months. The ribs in the Utility and Commercial grades combined were 8-, 20-, and 32-month-old steers. The Choice grade ribs were from 13-, 25-, and 37-month-old steers. Although only two grade groups were used in connection with these age groups, the data provide material for analyses and conclusions regarding the palatability of beef with these two ranges, and indicate certain trends in palatability as the animals grew older and also, with intensified feeding, as the beef improved in grade.

^{4/} Meat research work, Iowa State Experiment Station and U. S. Department of Agriculture 1926-28. Also report of Branaman, Hankins, and Alexander to American Society of Animal Production, 1936, based on similar research by specialists at Michigan State Experiment Station and U. S. Department of Agriculture. Similar studies at other State experiment stations appear to substantiate these reports.

Physical Composition of Beef and Its Palatability

The physical composition of beef consists of lean, fat, and bone. The factors in meat that determine its palatability are inherent in the lean and fat and are affected to some extent by the bone, especially when the lean, fat, and bone are cooked together. The proportions of fat to lean in the edible meat vary according to grade within any age group. Each of these component parts exerts an influence on the palatability of meat apparently in proportion to its presence in the meat.

The proportions of lean, fat, and bone in steer beef rib cuts (9th, 10th, and 11th ribs) of specified age groups are shown in table 1 for the Utility and Commercial grades combined, and for the Choice grade. The data on bone include ligaments and tendons. Similar rib cuts from the opposite sides were used for palatability tests which are recorded in table 2.

Table 1. - Proportions of lean, fat, and bone, by grades and age groups (steer ribs)

	: Utility and Commercial :				Choice ^{1/}	
Ages of animals ^{2/}	: 8 mos.	: 20 mos.	: 32 mos.	: 13 mos.	: 25 mos.	: 37 mos.
Lean - percent	: 73.16	: 69.23	: 72.97	: 56.92	: 52.48	: 57.12
Separable fat - percent	: 9.40	: 19.18	: 15.96	: 35.24	: 39.34	: 34.56
Edible portion - " ^{3/}	: 82.56	: 88.41	: 88.93	: 92.16	: 91.82	: 91.68
Bone - percent ^{4/}	: 17.44	: 11.59	: 11.07	: 7.84	: 8.18	: 8.32

^{1/} The cattle in the Choice grade were of the same herd from which the Utility and Commercial grade cattle were taken but were fattened about 5 months to attain the Choice grade.

^{2/} Data are based on the beef from 18 steers, carefully selected for grade and age from a large group of cattle. Three steers were so selected for each grade in each age group.

^{3/} Lean and fat.

^{4/} Includes ligament and tendons.

Source - Reports of Iowa Experiment Station, 1926-28. (9th, 10th, and 11th rib cut.)

Fat or finish is one of the factors used to determine the grade of an animal and of its meat. In general, the amount and relative proportions of fat in meat increase as the meat improves in grade. Apparently, the amount of lean also increases but the proportion of lean decreases in relation to fat as the grade of beef improves.

Palatability Factors

The palatability of beef is determined by a combination of the sensations experienced when eating it. Among the sensations are those caused by the aroma, flavor, tenderness, and juiciness of the meat. Although there may be others these four have been selected as the principal palatability factors that determine the degree of satisfaction experienced when eating beef.

Measuring Palatability Factors

Although the palatability sensations are known to vary in character or intensity according to grade and also according to age, little specific information has been generally available as to the causes or the degrees of such changes. In an effort to determine the causes and to measure their effects, State and Federal meat research workers have isolated the principal factors - aroma, flavor, tenderness, and juiciness - and have endeavored to apply to them quantitative or qualitative measurements so far as that was possible. The procedure for this purpose was to select an identical cut of meat - beef rib - from each carcass of carefully selected beef of each available grade in each age group. The physical characteristics and proportions of these rib cuts were noted and determined (table 1). Certain selected cuts (9th, 10th, and 11th ribs) were cooked under strict control. Each of the palatability factors was tested and appraised by trained meat judges. Whenever possible, their judgments, especially with reference to tenderness, were checked by mechanical apparatus. The results of such studies conducted by the Iowa Experiment Station and the U. S. Department of Agriculture are shown in table 2.

Table 2. - Palatability of steer beef ribs, by ages and grades

	Utility and Commercial grades:				Choice grade		
Ages of animals	8 mos.	20 mos.	32 mos.	13 mos.	25 mos.	37 mos.	
Live weight -	:	:	:	:	:	:	
shrunk, lb.	: 355.50	: 603.67	: 806.67	: 923.67	: 1,034.27	: 1,187.50	
Dressed weight - lb.	: 186.33	: 330.33	: 448.50	: 590.17	: 657.33	: 740.33	
Dressed yield -	:	:	:	:	:	:	
percent	: 52.41	: 54.72	: 55.60	: 63.89	: 63.56	: 62.34	
Palatability factor	: <u>Score</u>	: <u>Score</u>	: <u>Score</u>	: <u>Score</u>	: <u>Score</u>	: <u>Score</u>	: <u>Score</u>
scores: 1/	:	:	:	:	:	:	
Aroma	: 5.08	: 5.05	: 5.16	: 3.55	: 3.98	: 4.24	
Flavor - lean	: 17.57	: 18.32	: 18.69	: 22.55	: 24.68	: 25.75	
Flavor - fat	: 5.82	: 5.40	: 5.14	: 3.65	: 4.12	: 4.23	
Tenderness	: 17.83	: 19.20	: 17.58	: 21.99	: 21.89	: 21.60	
Juice - quality	: 11.13	: 11.57	: 12.44	: 11.37	: 11.92	: 13.11	
Juice - quantity	: 5.68	: 5.63	: 6.33	: 7.37	: 8.04	: 8.04	
Total palatability	:	:	:	:	:	:	
score	: 63.11	: 65.17	: 65.34	: 70.48	: 74.63	: 76.97	

1/ Committee judgments. (Lower number indicates a less desirable score.)

Source - Reports of Iowa Experiment Station, 1926-28.

When interpreting the data in this table it should be remembered that the higher number opposite any item represents a higher score or greater desirability from the palatability standpoint than the lower number; that the scores are the averages of the recorded judgments of meat judging committees, composed of representatives of the U. S. Department of Agriculture or of State colleges of agriculture, on a large number of samples in each grade and in each age group, and that the scores apply only to the 9th, 10th, and 11th rib cut.

Checking the data in table 1 with those in table 2 it is apparent that palatability varies with variations in the proportions of fat and lean, which means that it varies according to grades. It is apparent also that the palatability sensations vary also according to age groups within any grade.

Although the data on palatability apply only to the 9th, 10th, and 11th beef rib cut it is logical to assume that the palatability sensations from the other cuts in the same grades and age groups will vary similarly.

Fat and Palatability

Fat appears to be the predominating element in the physical composition of beef that affects its palatability. Fat increases materially as the grade improves, and as the grade of beef advances there is also noticeable improvement in its palatability. Fat in the low grades is naturally scarce. It is naturally abundant in the high grades.

The amount of fat in any grade varies according to age groups. Fat is less abundant in a calf of any grade than it is in an older animal of the same grade. Grade for grade, the yearling generally has more fat than the calf but less than the mature animal.

It appears, therefore, that the changes in palatability according to grade and age groups are related directly to changes in the proportion of fat because of the effects such changes have on aroma, tenderness, flavor, and juiciness of the lean and of the meat as a whole.

Table 2 shows that the changes in palatability according to age group are not as consistent and material as those caused by changes in grade or in the amount of fat. Age, however, appears to have a decided influence on the intensity of the total palatability sensations.

Chemical Composition and Palatability of Beef

In the foregoing statements the influence of fat on the palatability of beef has been stressed. Meat is eaten by most consumers, however, primarily for the pleasure they derive from the lean. Nevertheless according to the palatability data in table 2, the increasing proportions of fat in the beef as the grades improve add to three of the palatability factors-- the flavor of the lean, and the tenderness and juiciness of the beef as a whole -- but detract from the aroma of the beef and the flavor of the fat. The question naturally arises as to what are the factors in lean and fat that cause changes in the palatability of the meat as their proportions change. In an effort to find the answer to the question, State and Federal research workers have analyzed beef chemically or separated it into its component chemical parts of water, protein, fat, and ash and determined their proportions in beef of several grades. These workers do not claim, however, that the exact influence of each of these elements on palatability has been discovered.

Table 3 shows the chemical composition of the edible meat in beef in the low thirds of the Prime, Choice, and Good grades. (See also table 4.) Table 3 is included so the reader may visualize quickly the approximate quantitative differences in the proportions of the chemical elements in beef according to grades. The chemical element ash is omitted but it is negligible, amounting to less than 1 percent of the total weight of the edible meat of the carcass.

Table 3. - Water, protein, and fat in edible meat -
steer sides (chemical analysis)

	Low Prime	Low Choice	Low Good
	Percent	Percent	Percent
Water	40.3	45.4	50.9
Protein	11.8	13.6	14.9
Fat ^{1/}	33.6	22.2	13.5

^{1/} Ether extract method.

Source - Report by Branaman, Hankins, and Alexander to the Society of
Animal Production, November 1936.

The data on fat in table 3 indicate the amount of clear animal oil (by ether extract method). The water is the moisture content of the lean and of all connective tissues, including that which surrounds the physical fat. The protein is derived from the muscular fibers and all the connective tissues. The fat and protein are the principal sources of food values in meat.

The proportions of water and protein decrease along with the lean as the meat improves in grade. The chemical fat increases with the physical fat or as the meat improves in grade. Undoubtedly each element, including ash, exerts its own influence on the palatability or taste of beef and their combined effect on its palatability depends on the proportions in which they are present in the meat. At present, the data found through chemical analyses are more significant with reference to the food values of beef than to its palatability.

Table 4. - Physical and chemical compositions and palatability of steer beef, by grades

	Low	High	Low	High	Low
	Good	Good	Choice	Choice	Prime
Physical	Dressing yield, percent				
	Ratio meat to bone (side)				
	Ratio lean to fat $\frac{1}{1}$ (side)				
	Firmness of lean $\frac{1}{1}$ - score				
	Marbling, rib eye $\frac{1}{1}$ - score				
Chemical	Fat (ether extract - side) percent				
	Water (side) percent				
	Protein (side) percent				
	Fat (ether extract - rib) percent				
	Tenderness (cooked) - mechanical test $\frac{2}{2}$ lb.				
Palatability	Tenderness (cooked) - committee score $\frac{2}{2}$				
	Flavor of lean - intensity $\frac{2}{2}$ - score				
	Flavor of lean - desirability $\frac{2}{2}$ - score				
	Juice (quality) - score $\frac{2}{2}$				
	Juice (quantity) - score $\frac{2}{2}$				

1/ Scale 1 to 43. Lower numbers represent higher scores in firmness and marbling. (1 maximum, 43 minimum.)
 2/ Pounds to cut through.
 3/ Scale 1 to 7. Higher numbers represent higher scores or greater desirability. (1 minimum, 7 maximum.)
 Source - Report of Branaman, Hankins, and Alexander to the American Society of Animal Production, 1936.

Table 4 is a general summary which brings together in condensed form most of the supporting data that have been used as a general basis for this discussion. The data are so arranged as to make possible the study of the physical and chemical elements in beef as they, apparently, are related to palatability. Attention is called especially to the proportions, according to grades, of lean, fat, and bone to the ratio of edible meat to bone, and to the ratio of lean to fat in edible meat. Attention also is called to the chemical analyses showing the proportions of water, protein, and fat in edible meat, by grades.

As has been stated, and as shown in tables 1, 3, and 4, the palatability factors vary in intensity according to variations in the proportions of lean and fat, and the proportions of lean and fat vary according to grade and, to some extent, according to age. The quantities of the chemical elements in beef also vary with the proportions of lean and fat and therefore according to grade. This suggests that the various quantitative combinations of the chemical elements which occur with various combinations of lean and fat according to grade may be the primary causes of variations in palatability of beef. At any rate it appears that the palatability elements -- aroma and flavor -- are affected by the proportions of the chemical elements -- protein and fat. Certainly, juiciness is affected by the proportions of water and fat. It is possible, therefore, that the changes in palatability that accompany changes in the proportions of fat and lean along with changes in grade and age group may be caused at least to some extent by corresponding changes in the proportions of the chemical elements.

Although palatability in beef appears to be affected by various combinations of its chemical elements not enough is known about this for an adequate statement at this time. The remainder of this discussion, therefore, is limited to the obvious changes which occur, according to grade and age, in the selected palatability factors -- aroma, flavor, tenderness, and juiciness.

Palatability Factors Analyzed

Each of the palatability factors is analyzed below, separately and in combination with other factors, with special reference to their significance to the grades of beef. The effects of the degree of maturity on palatability also are considered. For these purposes the data in tables 2 and 4 were used.

Aroma: The data in table 2 indicate that the aroma of roasts from low-grade beef is more pleasing than that from similarly prepared roasts in the Choice grade. The much greater proportion of lean and connective tissue in the low-grade beef than in the high-grade seems to be the principal source or cause of its more pleasing aroma. Since lean and connective tissue are the principal sources of protein in meat, it would appear that the more intensive or more pleasing aroma of low-grade beef may be caused quite largely by or derived from protein.

Although the desirability of the aroma decreases definitely as the grade improves, there is a decided tendency for it to increase in any grade as the age of the animal advances. Such increase in the desirability of the aroma of roasts with the increase in age is noticeable and consistent in the Choice grade despite the obvious modifying effect on the aroma of beef in that grade produced by the greater amount of fat. This would indicate that the aroma of beef improves as the age of the animal advances despite the negative effect of fat on aroma as the grade improves.

Flavor of Lean: Intensity or desirability of the flavor of lean increases materially both as the grade improves and as the age of the animal advances. The increase in intensity of flavor of lean according to improved grade, however, is much greater than that according to advanced age. The rate of increase or improvement in flavor of lean by age groups, however, is much greater in the Choice grade than in the Utility and Commercial grades combined. The flavor of lean improves materially as the grade improves and quite noticeably within each grade and especially in the Choice or high grade as the age of the animal advances.

Flavor of Fat: The flavor of such fat as exists in the low grades apparently is more desirable than that of the fat in the high grades but decreases slightly in intensity in beef of the low grades as the age of the animal advances. (See table 2.) These decreases, no doubt, are caused by the greater amounts of fat in the meat of the older low-grade animals which may be sufficient to offset any influence age may have on the flavor of fat. (See table 1.) Although the flavor of the fat in high-grade beef is less desirable than that of the fat in the low-grade, it has a tendency to increase in intensity in high-grade beef as the age of the animals advances.

The apparent greater desirability of flavor of fat in the low grades over that of the high grades and its apparent improvement in the high grades as the age of the animal advances may not be due to an actual difference in the flavor of the fats. The fat in the low grades is scanty. When the lean and fat are cooked together the preponderance of lean and connective tissue in the low grades imparts a proportionate amount of the flavor of both to the fat so that it is difficult to isolate or identify the distinctive flavor of either fat or lean. Although the flavor of fat in the low-grade is apparently more desirable than in the high grade, the difference according to the age groups in any grade is not great. Furthermore, the trend in desirability of the flavor of fat in the low grades appears to be downward as the age of the animal advances. On the other hand, this trend is upward in the Choice grade. The chief effect of the fat on the palatability of beef apparently is its contribution to the flavor and tenderness of lean and to the quality and quantity of the meat juices.

The greater amount of fat in the high grades with its less desirable flavor and aroma apparently is tolerated by those who are averse to fat, because its presence and the conditions which accompany it improve the palatability of the beef as a whole.

Flavors of Fat and Lean Combined: The flavor of cooked fat is not like that of cooked lean when each is cooked separately. When fat and lean are cooked together some of the distinctive flavor of each is imparted to the other and the blended flavor of the cooked meat is not wholly like that of either of its component elements when they are cooked separately. There is a definitely improved trend in the combined flavors of fat and lean in cooked beef in any grade as the age of the animal advances but this improvement is not as pronounced in the low-grade beef as it is in the high-grade beef.

Aroma and Flavor Combined: Few consumers differentiate between aroma and flavor when eating cooked beef, and their judgment of the palatability of the beef insofar as flavor is concerned is based, more often than not, on their impressions of the aroma and flavor of fat and lean combined.

Although fat apparently has a tendency to reduce the aroma appeal of roast beef in proportion to its increased presence in the meat, it contributes materially to the desirability of the flavor of the lean portion and of the meat as a whole. The flavor of the lean of high-grade beef is much more desirable than that of the low-grade.

An examination of the data for aroma and flavor of lean and fat combined in table 2 reveals an improvement of these palatability elements combined in the low grades as the age advances. The rate of improvement, however, is slight. On the other hand, although the roasts of the Choice grade yearling (13 months old) are but slightly better in these respects than those in the low grades, there is a decided trend in the high grade toward improvement in combined aroma and flavor as the age advances. This would indicate that greater maturity and better finish combined result in more desirable aroma and flavor.

Tenderness: From table 2 it is apparent that beef becomes more tender as it improves in grade but less tender as the age of the animal advances. Toughness in meat, however, is natural. Strength of body requires strength or toughness in muscles. That, of course, means strength or toughness in muscle tissue, connective tissue, sinews, tendons, and all other physical elements contributing to the composition of the body. Many conditions such as environment, heredity, husbandry practices, habits, degree of nourishment, etc., affect the strength of tissues. The cooked roasts of beef from 20-month-old steers in the low grades are much more tender than those from the 32-month-old steers in the same grades. They are also more tender than roasts from 8-month-old steer calves as table 2 shows. This would indicate that the low-grade beef attains its greatest tenderness when the steer is around 20 months to 2 years old. Although there seems to be very little difference in the tenderness of cooked beef roasts according to age groups in the Choice grade, the beef from the young or 13-month-old steers appears to be slightly more tender than that from the older groups.

It is apparent, however, from the data in table 2 that there is a definite and consistent though slight trend toward greater toughness in high-grade beef as the age of the animal advances. In general, it would appear that beef in any grade from cattle of around 20 to 25 months of age is more tender than beef from cattle of older ages and that the tendency for the meat to become less tender appears to begin when the animal is, on the average, about 20 months old.

Apparently, beef from well-nourished animals, i.e., fat- or high-grade beef, is more tender than beef from undernourished or low-grade animals. There may be other contributing causes but fatness seems to be the principal cause of the greater tenderness in high-grade beef.

The grade of beef is determined quite largely by its degree of fatness. Tenderness is essential to high quality. The question arises, Why is fat- or high-grade beef generally more tender than beef that has less fat? The author submits the following in the hope of stimulating further consideration of this problem.

In high-grade beef the infiltration of fat particles in the form of marbling and invisible fat substances, together with the greater quantities of meat juices which are associated with the high grades, fill in, distend, and spread apart the muscle fibers and connective tissues to such an extent that fewer of them occupy a given space in high-grade beef than in beef of the lower grades. It is known that the fat cells increase in diameter 10 to 12 times in the process of fattening from the lowest to the highest grades of beef.^{5/} Some increase in the size of muscle cells, apparently, also inevitably occurs but not to the extent that the size of the fat cells increase. It would appear, therefore, that a cut of beef would be increasingly tender as its grade improves because of the resulting decrease in the amount of connective tissue in a given unit of cubic measurement. It is possible also that the connective tissue and cell walls or sheaths are somewhat weakened by such distension and thus probably add further to the tenderness of high-grade meats. These assumptions seem logical, but they have not been proved.

Meat Juices: It will be observed in table 3 that water constitutes a very large proportion of beef in any grade, especially of its lean and connective tissue. Much of the juiciness in meat is due to its natural water content, or the inherent moisture not lost in the process of cooking. The proportion of water or natural moisture content of beef decreases as its grade improves or as the proportion of fat increases according to grade. Although the moisture in meat is the principal source of its juiciness, such juiciness is augmented and enriched by the melted fats retained in the meat when cooked. Meat juices, therefore, are composed of a mixture of the natural moisture of the meat and of its melted fats.

^{5/} Moulton. Meat through the microscope, 1929.

Much moisture and fat escape in the cooking process but such as are retained in the meat after cooking determine the quantity and quality of its juiciness and to a large extent, therefore, its palatability. The fats that become a part of the juices are those that are melted and absorbed in the lean and tissues and thus blended with the remaining natural moisture in the meat to form the juices discussed here. As a rule, the more the natural moisture escapes from the meat while it is cooking, the more likely is the meat to be dry and less palatable or less pleasing to the taste. The latter result is especially noticeable in meat of the low grades. The abundance of fat in and surrounding the lean in high-grade beef apparently has a tendency to prevent the escape of moisture from such beef when the meat is cooked, so that it retains more of it than low-grade beef, which is not so well fortified with fat. The moisture and fat thus retained produce the high-quality juices that make the cooked meat of the high grades so much more palatable than that of the low grades. These juices vary in quality and especially in quantity according to grade and to a less extent according to age.

Quality of Juices: From the data in table 2 it appears that, although the quality of juices increases as the grade improves, the increase is not as great as might be expected. Since the quality of the juices was determined by the taste or by the reaction of the judges it is probable that the quality of the juices in the roast of the high-grade beef was discounted because of its fat content. Apparently the quality of juices improves steadily and consistently although not materially as the age of the animal advances.

Quantity of Juices: The quantity of juices retained in the cooked meat increases materially as the grade improves. Undoubtedly, much of this increase is caused by the inclusion of greater quantities of fat in the juices than is possible in low-grade meat. The degree of maturity seems to have little definite influence on the quantity of juice.

Quality and Quantity of Juices Combined: Consumers rarely differentiate between the quality and quantity of juices in cooked meat. To them juiciness usually means both quality and quantity. When these elements are so considered, consistent and material improvements are found according to grade and age groups within the grade.

Flavor, Tenderness, and Juiciness Combined: The three outstanding palatability factors in beef or those that are most generally observed by consumers are flavor, tenderness, and juiciness. An examination of the totals of the scores assigned to these three factors in table 2 shows that they agree in trend according to grades and age groups with the totals of all palatability scores, including those for aroma, despite the material discount for aroma in the Choice grade as compared with the aroma score for the low grade.

All Palatability Factors Combined: When the total scores for all palatability factors are considered it is quite apparent that high-grade beef is much more palatable than low-grade beef and that the beef becomes progressively and consistently more palatable in any grade as the age of the animal advances. (See table 2.) This apparently is true despite the fact that both the aroma of the meat and the flavor of the fat were discounted substantially in the palatability scores as the grade improved.

It is apparent, therefore, that the palatability of beef improves not only as the grade improves but also as the animal grows older. The latter applies especially to steers and heifers within the customary age limits at which the bulk of cattle are slaughtered for food. Comparable palatability data for cattle beyond 37 months old are not available. Since the maximum of tenderness in beef seems to be reached in beef from cattle around 20 months old and the meat generally becomes less tender thereafter, it seems probable that this factor alone might eventually reverse the palatability trend as the age of the animal advanced considerably beyond the 37 months for which palatability data are available.

Although the flavor of beef improves as the age advances the rate of improvement has a tendency to slow down in all grades as the animal grows older after it has reached maturity. This suggests that the trend of flavor desirability may be reversed as the age advances, as also seems probable in the case of tenderness.

The same conclusion seems justified with reference to the palatability of beef as a whole, since the total of all palatability scores shows that the rate of improvement in palatability according to age has a tendency to slow down in low-grade beef after an animal has attained about its twentieth month and in high-grade beef after it has attained about its twenty-fifth month. Thus it may be concluded that an animal eventually attains an age when the beef from it ceases to improve but begins to retrograde in its degree of palatability.

Summary and Conclusions

1. The grade of beef provides a general indication of its degree of palatability or of the degree of satisfaction the consumer may expect. The proportion of fat seems to be the prime factor in palatability as well as in the grade. This appears to be the case despite the fact that the aroma of the meat and the flavor of the fat are affected adversely by the great amount of fat in the high grades.

2. The palatability of beef is affected by the degree of maturity of the animal at time of slaughter. Beef from young cattle is less pleasing to the palate than beef from older cattle. The rate of improvement in the trend of palatability seems to be retarded after the animal has reached a certain age: The twentieth month in the case of high-grade beef; the twenty-fifth month for that of lower grade. It is reasonable to assume that the trend would eventually reach an ultimate point in improvement and become reversed as the age of the animal advanced.

3. Complete palatability data on all the 7 grades comparable to those for the Utility and Commercial combined and for the Choice grades are not available. From available palatability data on these two grade groups it would appear that beef in the highest grade is the most palatable and that in the lowest grade is the least palatable. The assumption also seems justified that the probable palatability scores for beef of the Good grade or the grade between Commercial and Choice will be somewhere between those for these two grade groups; that the scores from the Prime grade would be slightly better than those for the Choice grade, and that the scores for each succeeding grade below Utility would register consistent decreases in palatability as the grade declined.

4. Since available data have demonstrated progressive improvement in the palatability of beef from the low to the high grades, they attest to the soundness of the principle underlying the U. S. standard grades for beef to have the grades serve as a guide to consumers and the trade as to the relative palatability of beef.

5. Further research should be conducted in order to determine as definitely as possible the degree of palatability of each of the U. S. standard grades. Even though such information would be on an average and, at best, only approximate, that combined with information showing the physical composition and food value of beef according to grade, and descriptions of the various standard grades, would enhance the value of those standards for all, no matter what their particular interest in beef might be.

